nature of the bottom. A new map shows the distribution of deposits in the North Atlantic according to recent information, and an inset, based principally on the soundings of the *Britannia*, shows the outline of the Azores bank.

The lines of soundings fall naturally into three groups; those between the Azores and the British Islands, those between the Azores and North America, and those on the Azores bank. In each case new discoveries of interest have been made. On the first line a new depression, with soundings over 3000 fathoms, the "Peake deep," has been found; but the chief feature is the discovery of numbers of shoals rising steeply from over 2000 fathoms to within 1200 and 1400 fathoms of the surface, evidently the summits of submarine cones. The more southerly of the two lines between the Azores and North America revealed the important fact that the "tail" of the great Newfoundland bank extends much farther south than has hitherto been supposed. The *Britannia* has added largely to Thoulet's chart of the Azores bank, but the ground is so irregular that much sounding still remains to be done; the bank is described as being probably "a series of small hills, no doubt due to volcanic action."

The observations of bottom temperature, which were made with thermometers of Six's pattern, consist of two series of parallel lines, one double line between the Azores and the British Islands, and another between the Azores and America. It is pointed out that, on the whole, these observations give temperatures above the mean assumed in the *Challenger* report for this region of the ocean; but as that value is merely the average of the observations existing at the time, the volume of water at different temperatures not being taken into account, the difference may not be due to actual change. On the other hand, the *Britannia* observations show that in each of the double lines the temperatures are different; of the Azores-America line, the more northerly gave the higher readings at depths below 2000 fathoms; of the Azores-Europe line, the more southerly. It is suggested that these differences are due to actual change occurring between the dates of observation, and this view is supported by reference to the different temperatures observed in the south-west Pacific by H.M.S. *Egeria* in 1889 and H.M.S. *Penguin* in 1897. From the observations of H.M.S. *Jackal* in 1893, the writer showed that in the Færoe-Shetland Channel temperature was not constant at depths of at least 400 fathoms, and it was further shown that the variations were due to differences of level in the movements of water. The results of more recent work go to show that the active circulation of the eastern and western Atlantic consists chiefly of stream currents comparatively near the land, developed by the drift movements of the central areas and altogether separated by them. The currents on the eastern side are chiefly caused by the banking up of water from the west-wind drifts, and while most of this water escapes laterally to north and south, there is also a descending movement—hence the high temperatures in the depths. It is known that the horizontal streams are liable to great variations, partly seasonal, partly irregular, and the observations of the *Britannia* seem to prove that the vertical movements undergo corresponding changes. The variations of temperature may be regarded as directly due to movements of water, and therefore as seasonal in only a secondary sense, if at all.

The samples of deposits collected by the *Britannia*, numbering 432, are very fully described by Sir John Murray. The map shows two considerable alterations when compared with that of the *Challenger* report. First, the red clay area is extended northward from the deep water round Bermuda and passes directly into the blue mud south of Newfoundland. This abrupt transition to a terrigenous deposit is accounted for by the great distance to which continental detritus is carried by icebergs. Second, the pteropod ooze region round the Azores is restricted to a smaller area than before, although it is noted that the characters of this deposit are not well marked, and that it is difficult to classify some samples as pteropod or globigerina with certainty. Many samples from moderate depths near the Azores contain fewer pteropods than those obtained from deeper water farther north.

H. N. D.

OUR BOOK SHELF.

Modern Astronomy. Being some Account of the Astronomical Revolution of the last Quarter of a Century. By H. H. Turner, F.R.S. Pp. xvi+286. (Westminster: Archibald Constable and Co., Ltd., 1901.) Price 6*s*. net.

THE Savilian professor is so strongly impressed with the magnitude of the changes which have taken place in astronomical methods during the last quarter of a century that he does not hesitate to describe them as revolutionary. The task which he has set himself in this book is to give a brief review of the present situation, pointing out the nature of the changes rather than giving a complete account of them or of the discoveries to which they have led. The book can thus in no sense be regarded as a reference or text-book, but it may be remarked that elementary explanations have usually been introduced to make the matter generally intelligible.

Several quotations are given as an indication that about 1875 there was a feeling that novelties in astronomical methods or results were no longer to be expected. Such a feeling, if it existed, was certainly premature. New instruments of precision have been invented or erected; telescopes of increased size and novel construction have been made; photography has come to aid the astronomer in numberless ways; astrophysics has become an important branch of the subject, with almost boundless possibilities; and even in mathematical astronomy new methods of treating the lunar and planetary theories have been introduced.

This progress is treated under the four heads, "Modern Instruments," "Modern Methods," "Modern Results" and "Modern Mathematical Astronomy." Occasional overlapping and repetition is the natural outcome of this classification, but the book provides an interesting and fairly connected account of several departments of astronomical work. The treatment of astrophysics, however, leaves much to be desired. There is practically nothing in the book relating to the great advances in our knowledge of the sun as a result of recent eclipse work, and it is especially to be regretted that the evidences of stellar evolution are not more fully set forth. There are other indications of the author's unfamiliarity with the progress of astrophysics; on p. 239, for instance, he states that no supposition allied to that of a revolving companion will explain the variability of stars in clusters, whereas the collisions of revolving swarms of meteorites at periastron explain the light curves completely. For the sake of historical accuracy,

it should have been stated on p. 91 that the original idea of the spectroheliograph was due to Dr. Janssen, who first suggested it at the Exeter meeting of the British Association in 1869. Again, with reference to the first observation of the spectrum of a nebula, it is stated (p. 242) that "it was seen at a glance that the spectrum consisted of a few bright lines," though the observer at first attributed what he saw to some possible derangement of his instrument.

Looking forward, Prof. Turner believes that, among other changes, the transit circle will be gradually superseded by the almucantar for star observations, and by the heliometer for observations of the positions of planets, and in celestial photography he predicts a great future for the portrait lens.

The illustrations, some thirty in number, are of indifferent quality, and that of Eros, on p. 109, is almost unintelligible.

Chemistry an Exact Mechanical Philosophy. By Fred. G. Edwards, Inventor of Atomic Models. Pp. xii + 100. (London: J. and A. Churchill, 1900.)

"THE object of this work is to determine the exact shape of the atoms, to find their relative position in space, and to show that chemical force is purely a function of matter and motion." Further, "the shapes obtained for the different atoms is the subject-matter of a British patent (atomic models) dated 1897." Again, "the conclusions herein deduced (when accepted as true) will form a fitting climax to the discoveries of a century which has produced the atomic theory of Dalton, the theory of heat as a mode of motion, and the discoveries of the correlation of physical forces, and that force, like matter, is indestructible."

For the scientific reader there is little need to add any comments to these quotations. There is, however, always the possibility that an author may have a good idea but an unfortunate way of presenting it, and one does not forget that "the law of octaves" was received with something like ridicule. It is necessary to add, therefore, that a careful examination of the present work, made with every desire to find precious metal in it, has failed to reveal anything that seems likely to aid the advancement of science.

In dealing with the *exact shape* of atoms, the author starts with the assumption that the lightest known element, hydrogen, consists of two tetrahedra placed base to base, and that the atoms of the whole of the remaining elements may be similarly formed by tetrahedra built up symmetrically, every two tetrahedra representing one unit of atomic weight. It is practically impossible, without the models before one, to judge whether there is any outcome from this view of things that compensates in any degree for its arbitrariness and complexity. There can be little question, however, that as a whole the book and its doctrines will not command the serious attention of men of science whose leisure and patience are limited. A. S.

The Chemists' Pocket Manual. By R. K. Meade, B.S. Pp. vii + 204. (Easton, Pennsylvania: The Chemical Publishing Co., 1900.)

A LARGE amount of information of use to professional chemists is brought together in this pocket book. The tables include almost everything to which occasional reference has to be made in chemical laboratories; and with the formulæ, calculations, physical and analytical methods, should be of service not only to chemists, but also to assayers, metallurgists, manufacturers and students. Among the points worthy of special mention are the applications of graphic methods to conversion tables; and the descriptions of select methods of technical analysis.

LETTERS TO THE EDITOR.

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The Use of the Method of Least Squares in Physics.

THE application of the method of least squares to physical measurements is described in several standard text-books—to wit, Kohlrausch's "Introduction to Physical Measurements" (third edition, 1894), Stewart and Gee's "Elementary Practical Physics" (1885), and others. In none of these is it pointed out that the method *as set forth* offers in certain cases a choice of results, and that the solution is practically unique only if a sufficient number of observations be taken. Nor is any indication given how the method is to be applied when none but a small number of observations is available. Since the method is intended for use only when a high degree of refinement is aimed at, these points are of practical importance.

As illustrating the necessity for examining the matter, we may take the example given by Kohlrausch on p. 13 of the book referred to above. The object is to determine the law connecting the length L and temperature θ of a standard metre bar from the following four observations:—

θ . . . . = 20°, 40°, 50°, 60°

l (the excess over 1 metre) = ·22mm., ·65mm., ·90mm., 1·05mm.

The law deduced is

$$L = 999{\cdot}804 + 0{\cdot}0212\theta.$$

It is not, however, pointed out that the law would be different if the equation connecting x and y, in this case θ and l, were written to begin with in a slightly different form. On the contrary, the above solution is presented as if it were altogether beyond doubt.

In the working of the example as given by Kohlrausch, the equation is written

$$y - ax - b = 0;$$

but if it be written

$$cy - x - d = 0,$$

and exactly the same procedure as that adopted in evaluating a and b be followed in determining c and d, the law thence deduced from the observations becomes

$$L = 999{\cdot}800 + 0{\cdot}0213\theta.$$

It will be seen that the constants in these two laws differ by one in two hundred, or 0·5 per cent., as regards the significant figures; and that from the precisely similar way in which they are obtained, they are each equally entitled to recognition.

In fact, corresponding to the values for a and b usually given, viz.:—

$$a = \frac{\Sigma x \Sigma y - n \Sigma xy}{(\Sigma x)^2 - n\Sigma x^2}; \quad b = \frac{\Sigma x \Sigma xy - \Sigma x^2 \Sigma y}{(\Sigma x)^2 - n \Sigma x^2},$$

there are always another pair of values, giving the second form of the law, viz.:—

$$a' = \frac{(\Sigma y)^2 - n\Sigma y^2}{\Sigma x \Sigma y - n \Sigma xy}; \quad b' = -\frac{\Sigma y \Sigma xy - \Sigma y^2 \Sigma x}{\Sigma x \Sigma y - n \Sigma xy}.$$

The first pair of values corresponds to the supposition that the x measurements are guaranteed correct, and the experimental errors are all confined to the y measurements; and the second pair corresponds to the supposition that the y measurements are correct and the errors are all in the x measurements. The two lines

$$y = ax + b$$
$$y = a'x + b'$$

intersect at the centre of mass of the system of points obtained by plotting the observations.

The question naturally arises: How shall a relatively small number of observations, or a series of observations which are relatively discordant, be made to furnish the best mean result obtainable when no other observations are available?

In order to answer this question, we may recur to the remark above that differences in the result are obtained by writing the equation in different forms. The various forms of the equation correspond to the several directions in which the divergencies of